Course guide
295624 - 295MB111 - Numerical Analysis and Modelling

Last modified: 01/07/2025

Unit in charge: Barcelona East School of Engineering
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN ADVANCED BIOMEDICAL TECHNOLOGIES (Syllabus 2025). (Optional subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: Jiménez Jiménez, Maria Jose
Muñoz Romero, Jose Javier

Others: Carmona Mejias, Angeles
Encinas Bachiller, Andres Marcos
Martín Llopis, Àlvar

PRIOR SKILLS

Calculus in one and several variables; Linear algebra; Differential Equations, Programming

LEARNING RESULTS

Knowledges:
K2. Recognise advanced data analysis and modelling structures.

Skills:
S6. Interpret biomedical data using data analysis, machine learning and deep learning techniques.

Competences:
C6. Integrate the values of sustainability and understand the complexity of systems, with the aim of undertaking or promoting actions that restore and maintain the health of ecosystems and improve justice, thereby generating visions of sustainable futures.
C4. Use information resources effectively, manage the acquisition, structure, analysis and visualisation of data and information in the area of specialisation and critically assess the results.
C5. Use scientific and technical information to respond to any demand for modification, innovation or improvement of devices, products and processes linked to biomedical engineering for new scientific or technological applications.

TEACHING METHODOLOGY

Presentation of theoretical contents.
Resolution of exercises, problems and cases.
Discussion of problems or scientific articles.
Completion of individual and group projects.
Tutorial sessions in computer room and simulations.

LEARNING OBJECTIVES OF THE SUBJECT

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STUDY LOAD

Type	Hours	Percentage
Hours large group	21,0	14.00
Hours small group	21,0	14.00
Self study	108,0	72.00

Total learning time: 150 h

CONTENTS

Modelling dynamical systems.

Description:
Description: Modelling and solving dynamical systems for predicting temporal evolution.

Specific objectives:
-Topic 1. Non-linear systems of equations: Newton-Raphson and quasi-Newton. Applications to optimisation.
-Topic 2. Numerical methods for ODEs: Euler and Runge-Kutta. Explicit and implicit methods. Stability and conditioning.
-Topic 3. Application to epidemiological models (SIR). Population dynamics and networks of neurons.

Related activities:
Implementation of simple models with two and three variables.
Application to epidemiological problems (SIR model: Sane-Infected-Recovered). Simulation of scenarios and actuations.
Application to dynamics systems of neurons mad synaptic signalling.

Full-or-part-time: 10h 30m
Theory classes: 5h 15m
Practical classes: 5h 15m

Optimization and parameter fitting

Description:
Understand and solve optimisation problems numerically. Fitting of parameters from experimental data.

Specific objectives:
- Topic 1 Optimisation algorithms. Optimality conditions, gradient and descent methods, line search and genetic algorithms.
- Topic 2 Fitting methods: least-square, maximum likelihood.
- Topic 3 Case studies: parameter fitting in tumour growth problems and viscoelastic materials.

Related activities:
Optimisation of pharmaco-kinetic model and characteristic time in viscoelastic tissues.

Full-or-part-time: 10h 30m
Theory classes: 5h 15m
Practical classes: 5h 15m

Linear Partial Differential Equations

Description:
Description: Understand and solve optimisation problems numerically. Fitting of parameters from experimental data.

Specific objectives:
- Topic 1 Optimisation algorithms. Optimality conditions, gradient and descent methods, line search and genetic algorithms.
- Topic 2 Fitting methods: least-square, maximum likelihood.
- Topic 3 Case studies: parameter fitting in tumour growth problems and viscoelastic materials.

Related activities:
Optimisation of pharmaco-kinetic model and characteristic time in viscoelastic tissues.'

Full-or-part-time: 10h 30m
Theory classes: 5h 15m
Practical classes: 5h 15m

Reaction-diffusion models and scattering

Description:
Understand, model and solve spatio-tmeporal problmes in biology.

Specific objectives:
- Topic 1. Examples of reaction-diffusion. Stability. Application to Turing patterns.
- Topic 2. Scattering problems. Inverse problems and tomography problems.

Related activities:
Application to image analysis problems, and pattern emergence in growth.

Full-or-part-time: 10h 30m
Theory classes: 5h 15m
Practical classes: 5h 15m

GRADING SYSTEM

Marks of Tutorials 1st part (T1) = 17.5%
Marks of Tutorials 2nd part (T2) = 17.5%
Course Work (CW) = 30%
Theory Exam (TE) = 35%
Final mark (FM)= 0.175*T1 + 0.175*T2 + 0.30*CW+ 0.35*TE

BIBLIOGRAPHY

Basic:
- Ascher, U. M.; Petzold, L. Computer methods for ordinary differential equations and differential algebraic equations. Philadelphia: SIAM, 1998. ISBN 9780898714128.
- Murray, J. D. Mathematical Biology II : spatial models and biomedical applications. Third edition. New York: Springer, 2003. ISBN 0387952284.
- Nocedal, Jorge; Wright, Stephen J. Numerical optimization. 2nd ed. Berlin: Springer, cop. 2006. ISBN 9780387303031.
- Haberman, Richard. Ecuaciones en derivadas parciales : con series de Fourier y problemas de contorno. 3a ed. Madrid [etc.]: Prentice Hall, cop. 2003. ISBN 8420535346.
- Johnson, Claes. Numerical solution of partial differential equations by the finite element method. Cambridge [etc.]: Cambridge University Press, cop. 1987. ISBN 0521347580.

Complementary:
- Iserles, A. A First course in the numerical analysis of differential equations. 2nd ed. Cambridge [etc.]: Cambridge University Press,

2009. ISBN 9780521734905.

RESOURCES

Other resources:
Class material avalaible in ATENEA